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6-18-02 E.Hall

Attorney's Docket No.: 02052-087001 / 98,009

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Peter Daniel HANSEN et al.	Art Unit	:	2121
Serial No.	:	09/503,508	Examiner	:	Sheela S. Rao
Filed	:	February 14, 2000			
Title	:	INTELLIGENT VALVE FLOW LINEARIZATION			

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APPEAL BRIEF

(1) Real Party in Interest

Invensys Systems, Inc. (formerly The Foxboro Company) is the real party in interest.

(2) Related Appeals and Interferences

There are no related appeals or interferences.

(3) Status of Claims

Claims 1-15 are pending in this application, with claim 1 being independent.

All of the claims stand rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 5,251,148 (Haines).

(4) Status of Amendments

The claims have not been amended subsequent to the final rejection.

(5) Summary of Invention

The invention relates to a valve positioner system that controls fluid flow in a flow line.

A valve positioner system includes a valve flow modulating member that defines an area through which fluid flows along the flow line, a valve stem coupled to the valve flow modulating member, and an electric actuator that controls the valve flow modulating member with the valve stem. A force or torque generated by the actuator changes a position of the valve stem, which causes the valve flow modulating member to move, thus adjusting the fluid flow area through the valve flow modulating member. The flow rate of the fluid is adjusted according to the

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adjustment of the valve flow modulating member area. Page 4, line 25 to page 5, line 10 and Fig. 1.

The valve positioner system includes a valve positioner coupled to the actuator and to a position sensor. The position sensor is coupled to the valve stem to measure a position of the valve stem, thus closing the loop between the valve stem and the valve positioner. The valve positioner compares a target valve stem position to an actual valve stem position that is measured by the position sensor and adjusts a pressure in the actuator until the valve stem position matches the target valve stem position. Page 5, lines 1-20; page 6, lines 19-23; and Fig. 1.

The valve positioner system includes a feed-forward flow control correction that may be implemented as a feed-forward controller connected to the valve positioner. The feed-forward controller determines a target valve stem position based on a target fluid flow rate that results from an upstream controller or from manual adjustment. The feed-forward controller provides the target valve stem position to the valve positioner. Page 6, lines 10-23 and Fig. 4.

In particular, the feed-forward controller calculates a target valve flow area from the target flow rate and a user configured tuning parameter or pressure coefficient using a special relationship between the target flow rate, the target valve flow area, and the pressure coefficient. Then, using a predetermined function, the feed-forward controller determines the target valve stem position that corresponds to the calculated target valve flow area. The predetermined function is provided by the manufacturer of the valve assembly. In one implementation, the function is dependent on maximum and minimum flow areas. Page 7, lines 21-28 and Fig. 4.

The special relationship is determined by modelling fluid flow rate through the flow line and the valve flow modulating member. The modelling begins by calculating a relationship between a difference in pressure squared across the flow line relative to a mass flow rate and the area of the valve flow modulating member. Using this calculated relationship and making some additional assumptions about the system, it is determined that the valve flow area (y), the flow rate (ν), and the pressure coefficient (β) are related by:

$\frac{1}{\nu} = (1-\beta) + \frac{\beta}{y^2}$, if the fluid is a liquid; and

$\frac{1}{\nu^2} = (1-\beta) + \frac{\beta}{y^2}$, if the fluid is a gas. Page 8, line 5 to page 13, line 15 and Fig. 4.

In summary, the feed-forward controller receives a target flow rate and the pressure coefficient to calculate a target flow area. Using the predetermined function, the target valve stem position is calculated. The target valve stem position is fed into the valve positioner, which adjusts the pressure in the actuator to change the valve stem position and cause a change in the flow rate of the fluid through the flow line. Page 14, lines 1-8 and Fig. 4.

Additionally, the position sensor provides a measured valve stem position to the valve positioner, which sends the measured valve stem position to the feed-forward controller. The feed-forward controller performs a back calculation to provide a flow feedback signal to an upstream controller. To accomplish this, the feed-forward controller uses the inverse of the predetermined function to calculate a flow area that corresponds to the measured valve stem position. Using the calculated flow area, the feed-forward controller performs an inverse calculation to determine a flow rate that corresponds to the measured valve stem position. This determined flow rate may be used to help initialize an upstream controller. Page 14, lines 9-22 and Fig. 4.

(6) Issues

Is the subject matter of the claims anticipated by Haines?

(7) Grouping of Claims

The claims do not stand or fall together. The claims are believed to fall within seven separately patentable groups as follows: claims 1 and 8-15; claim 2; claim 3; claim 4; claim 5; claim 6; and claim 7. The reasons that the claims do not stand or fall together are presented in the Argument section below.

(8) Argument

THE SUBJECT MATTER OF THE CLAIMS IS NOT ANTICIPATED BY HAINES AND WOULD NOT HAVE BEEN OBVIOUS IN VIEW OF HAINES

Claim 1

Independent claim 1 recites an open loop method of controlling flow rate of a fluid through a valve flow modulating member that is controlled by a position of a valve stem. The method includes setting a target flow rate and determining a target valve stem position based on the target flow rate. Additionally, the method includes adjusting the valve stem position until a position of the valve stem matches the target valve stem position.

The Examiner has rejected claims 1-15 under 35 U.S.C. §102(b) as being anticipated by Haines. Haines uses an "integrated process control valve" having a valve body, a valve plug, and a valve stem that is controlled by an actuator positioned on the valve body to control "the flow of a fluid through [a] valve." See Haines at col. 2, lines 5-7; col. 3, lines 40-51; and Figs. 1 and 2. Additionally, a positioner is coupled to a piston on the valve stem to cause the piston to move and a sensor arm is mounted to detect the position of the valve stem. See Haines at col. 4, lines 10-25 and Figs. 1 and 2. A controller is coupled to the control valve "for calculating the flow rate of liquid in the valve body." See Haines at col. 7, lines 12-14 and Figs. 1 and 2. The calculated flow rate "may ... be used to ... provide an indication to the controller as to which direction the valve plug must be moved to change the flow rate and thus bring it closer to a predetermined desired flow rate value." See Haines at col. 7, lines 58-64.

Haines fails to describe or suggest determining a target valve stem position based on a target flow rate, as required by claim 1. Rather, Haines determines a valve actuator position based on inlet and outlet pressures of the valve body or based on the previous valve actuator position. In particular, as Haines details, "[a] utilization device receives and processes the first and second signals and develops control signals for application to the actuator to cause the actuator to move the throttling element in a manner dependent upon the values of the first and second signals," which represent, respectively, inlet and outlet fluid pressures. See Haines at col. 2, lines 32-51. Additionally, Haines explains that the "position of the stem ... is mechanically converted into a force ... and then compared to a force representing an input signal from the

controller ... to ascertain the difference in values of the forces. The positioner ... causes the piston 68 to move until the signal values match, indicating that the piston, and thus plug 28, has been moved to the correct position." See Haines at col. 4, lines 10-29.

Moreover, although Haines uses calculated flow rates in the analysis, the calculated flow rates are used to determine a target flow rate, and not a target position. Haines details

> calculated flow rate may either be used to apprise the user ... or to provide an indication to the controller as to which direction the valve plug must be moved to change the flow rate and thus bring it closer to a predetermined desired flow rate value. The controller would develop the appropriate signal for supply to the valve positioner to cause the valve positioner to change the position of the valve plug, after which measurements and calculations to obtain the flow rate would again be made. This process would be repeated until the desired flow rate were achieved. See Haines at col. 7, lines 58-64.

In making the rejection, the Examiner argues in the final action that "Haines, et al. teach of a throttle element which is movable to selectively vary the flow rate of fluid flowing, see column 2 lines 36-37 and column 5, lines 22-30." However, as discussed above, the first passage merely describes that the actuator is moved based on the inlet and outlet pressures. Furthermore, the second passage merely describes that the actuator position is determined and does not describe or suggest that the actuator position is determined based on a target flow rate. For example, the second passage explains "the position of the piston 68 and thus stem 32 as determined by the arm 92," which senses the position of the stem clamp. See Haines at col. 4, lines 10-13.

Haines also fails to describe or suggest adjusting a valve stem position until the valve stem position matches the target valve stem position, as also required by claim 1. The Examiner argues that "Haines goes on to explain the adjustment of the valve stem position based on the pressure signals received by sensors. A utilization device receives these signals and then develops control signals used to move the throttle element as required; thereby adjusting the throttle to a position that matched the flow rate (see column 2, lines 40-51 and column 8, lines 47-51)." Appellant disagrees. Although Haines shows that the valve stem position is adjusted, Haines does not describe or suggest adjusting the valve stem position "until a position of the valve stem matches the target valve stem position," as required by claim 1. Indeed, the Examiner

fails to make this argument, but merely points to col. 8, lines 47-51 of Haines and states that the position is adjusted to match the flow rate, which is not even a feature of claim 1. Moreover, the passage identified by the Examiner merely describes adjustment of the valve stem position until a flow rate matches a target flow rate, that is, "to change the flow rate and thus bring it closer to a predetermined desired flow rate value." See Haines at col. 7, lines 60-64 and col. 8, lines 47-51. The Examiner also points to col. 2, lines 40-51 of Haines, which, as discussed above, merely shows that adjustment of the valve stem position is based on inlet and outlet pressures.

The Examiner also argues in the final rejection that a "target flow rate is inherent to such systems wherein pressure or fluid flow is present. Too much or too little pressure or flow of fluid can be detrimental; therefore, establishing an appropriate level or rate is essential for proper production." Appellant does not dispute whether a target flow rate is inherent in Haines. Nevertheless, the Examiner has still failed to show in Haines a determination of a target valve stem position based on the target flow rate, which is recited in claim 1.

Accordingly, the rejection of claim 1 should be reversed, as should the rejection of claims 8-15, which depend from claim 1. The rejection of claims 2-7 should be reversed for at least the reasons that the rejection of claim 1 should be reversed and for the following additional reasons.

Claim 2

Dependent claim 2 recites that determining the target valve stem position includes determining a pressure coefficient, calculating a flow area of the valve flow modulating member, and determining a valve stem position corresponding to the calculated flow area. Haines fails to describe or suggest determining a target valve stem position by calculating a flow area of the valve flow modulating member. Moreover, the Examiner has failed to provide or discuss, in either office action, a citation in Haines that shows the features of claim 2. Accordingly, appellant requests reversal of the rejection of claim 2 for these additional reasons.

Claim 3

Dependent claim 3 recites that calculating the flow area of the valve flow modulating member includes using the target flow rate and the determined pressure coefficient. Haines fails to describe or suggest calculation of the flow area using a target flow rate and a determined

pressure coefficient. Pointing to claims 1-10 of Haines, the Examiner states that "the claims of the patented invention disclose the features of the instant claims by expressing the variables for calculating the parameters, i.e. pressure and temperature, of the control method as claimed." Although a flow area is mentioned in claims 1 and 2 of Haines, which recite that "the cross-sectional area of flow of at least a portion of the passage" is varied, neither claim describes or suggests calculation of the flow area using a target flow rate and a determined pressure coefficient, as recited in claim 3. Accordingly, appellant request reversal of the rejection of claim 3 for these additional reasons.

Claim 4

Dependent claim 4 recites that determining the valve stem position includes using a predetermined relationship between the valve stem position and the flow area. Haines fails to describe or suggest using a predetermined relationship between a valve stem position and a flow area to determine a valve stem position. The Examiner has failed to provide or discuss, in either office action, a citation in Haines that shows the features of claim 4. Accordingly, appellant requests reversal of the rejection of claim 4 for these additional reasons.

Claim 5

Dependent claim 5 recites that calculating the flow area of the valve flow modulating member includes modelling flow rate through the valve flow modulating member to determine a relationship between a function of fluid pressure upstream and downstream from the valve flow modulating member, the flow area of the valve flow modulating member, and the flow rate through the valve flow modulating member. Haines fails to describe or suggest modelling flow rate through a valve flow modulating member to determine such relationships. Pointing to claims 1-10 of Haines, the Examiner states that "the claims of the patented invention disclose the features of the instant claims by expressing the variables for calculating the parameters, i.e. pressure and temperature, of the control method as claimed." The flow rate is mentioned in claim 5 of Haines, which recites that the flow rate of the fluid is determined from pressure of fluid at the inlet (first signal), pressure of fluid at the outlet (second signal), temperature of the fluid in the flow passage (third signal), and flow capacity of the valve body (fourth signal). As is

evident, the flow rate described in claim 5 of Haines is not modelled to determine relationships between a fluid pressure function, a flow area, and a flow rate. The flow rate is again mentioned in claims 6 and 7 of Haines, which recite that the flow rate is determined in accordance with a relationship. Again, these claims fail to describe or suggest that the flow rate is modelled to determine relationships between a fluid pressure function, a flow area, and a flow rate. Lastly, the flow rate is mentioned in claim 8 of Haines, which recites that the flow rate value is stored and compared with a determined flow rate to produce a "difference signal whose magnitude represents the difference between the compared values." Claim 8 also recites that the flow rate is varied to "more closely match the stored flow rate value and reduce the magnitude of the difference signal." However, claim 8 fails to describe or suggest that the flow rate is modelled. Accordingly, appellant requests the reversal of the rejection of claim 5 for these additional reasons.

Claims 6 and 7

Dependent claim 6 recites that the modelling assumes that an internal energy of the fluid is constant across the valve flow modulating member and dependent claim 7 recites that the modelling assumes that a density of the fluid remains substantially constant across the valve flow modulating member. As discussed above with respect to claim 5, Haines fails to describe or suggest modelling of the flow rate. Moreover, although the Examiner again points to claims 1-10 of Haines, claims 5-8 of Haines (which are the only ones of these claims to mention a flow rate) fail to describe or suggest such modelling. Thus, Haines fails to describe or suggest that modelling assumes that an internal energy of the fluid is constant across the valve flow modulating member, as required by claim 6, or that modelling assumes that a density of the fluid remains substantially constant across the valve flow modulating member, as required by claim 7. Accordingly, appellant requests reversal of the rejection of claims 2-7 for these additional reasons.

Conclusion

For the foregoing reasons, the rejection should be reversed.

Enclosed is a check for $320 to cover the fee for this appeal brief. Additionally, a check for $110 is enclosed to cover the one month extension of time fee. Please apply any other charges or credits to Deposit Account No. 06–1050.

Respectfully submitted,

Date: June 10, 2002

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Appendix of Claims

1. An open loop method of controlling flow rate of a fluid through a valve flow modulating member that is controlled by a position of a valve stem, the method comprising:

setting a target flow rate;

determining a target valve stem position based on the target flow rate; and

adjusting the valve stem position until a position of the valve stem matches the target valve stem position.

2. The method of claim 1, wherein determining the target valve stem position comprises:

determining a pressure coefficient;

calculating a flow area of the valve flow modulating member; and

determining a valve stem position corresponding to the calculated flow area.

3. The method of claim 2, wherein calculating the flow area of the valve flow modulating member comprises using the target flow rate and the determined pressure coefficient.

4. The method of claim 2, wherein determining the valve stem position comprises using a predetermined relationship between the valve stem position and the flow area.

5. The method of claim 2, wherein calculating the flow area of the valve flow modulating member comprises modelling flow rate through the valve flow modulating member to determine a relationship between a function of fluid pressure upstream and downstream from the valve flow modulating member, the flow area of the valve flow modulating member, and the flow rate through the valve flow modulating member.

6. The method of claim 5, wherein the modelling assumes that an internal energy of the fluid is constant across the valve flow modulating member.

7. The method of claim 5, wherein the modelling assumes that a density of the fluid remains substantially constant across the valve flow modulating member.

8. The method of claim 2, wherein the fluid is in a gaseous state.

9. The method of claim 8, wherein calculating the flow area of the valve flow modulating member comprises estimating a pressure of the fluid upstream from the valve flow modulating member and a pressure of the fluid downstream from the valve flow modulating member.

10. The method of claim 8, wherein the pressure coefficient includes a squared pressure difference ratio.

11. The method of claim 8, wherein the pressure coefficient is estimated using maximum and minimum flow conditions.

12. The method of claim 2, wherein the fluid is in a liquid state.

13. The method of claim 12, wherein the pressure coefficient is estimated using maximum and minimum flow conditions.

14. The method of claim 12, wherein calculating the flow area of the valve flow modulating member comprises estimating a pressure of fluid upstream from the valve flow modulating member and a pressure of the fluid downstream from the valve flow modulating member.

15. The method of claim 12, wherein the pressure coefficient includes a ratio of the difference in the upstream pressure and the downstream pressure when the valve flow modulating member is fully open to the difference in the upstream pressure and the downstream pressure when the valve flow modulating member is fully closed.